Climate drivers and climate changes in the Columbia River basin

Philip Mote
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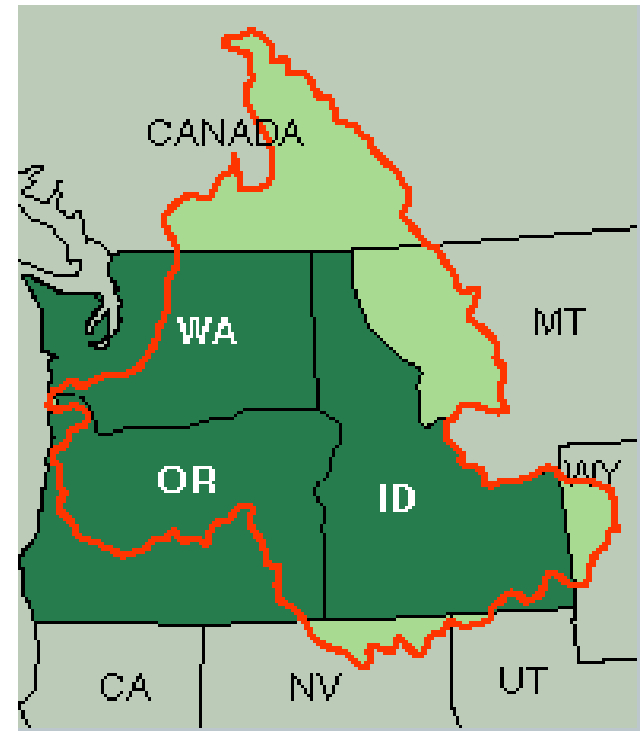
The Climate Impacts Group

http://cses.washington.edu/cig/



Goal: help the Pacific Northwest become more resilient to climate variations and climate change

Supported by NOAA Climate Program Office as part of the Regional Integrated Science and Assessments (RISA) program

NOAA

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Outline

- Interpreting regional climate variability and change
- Observed changes here
- Future climate

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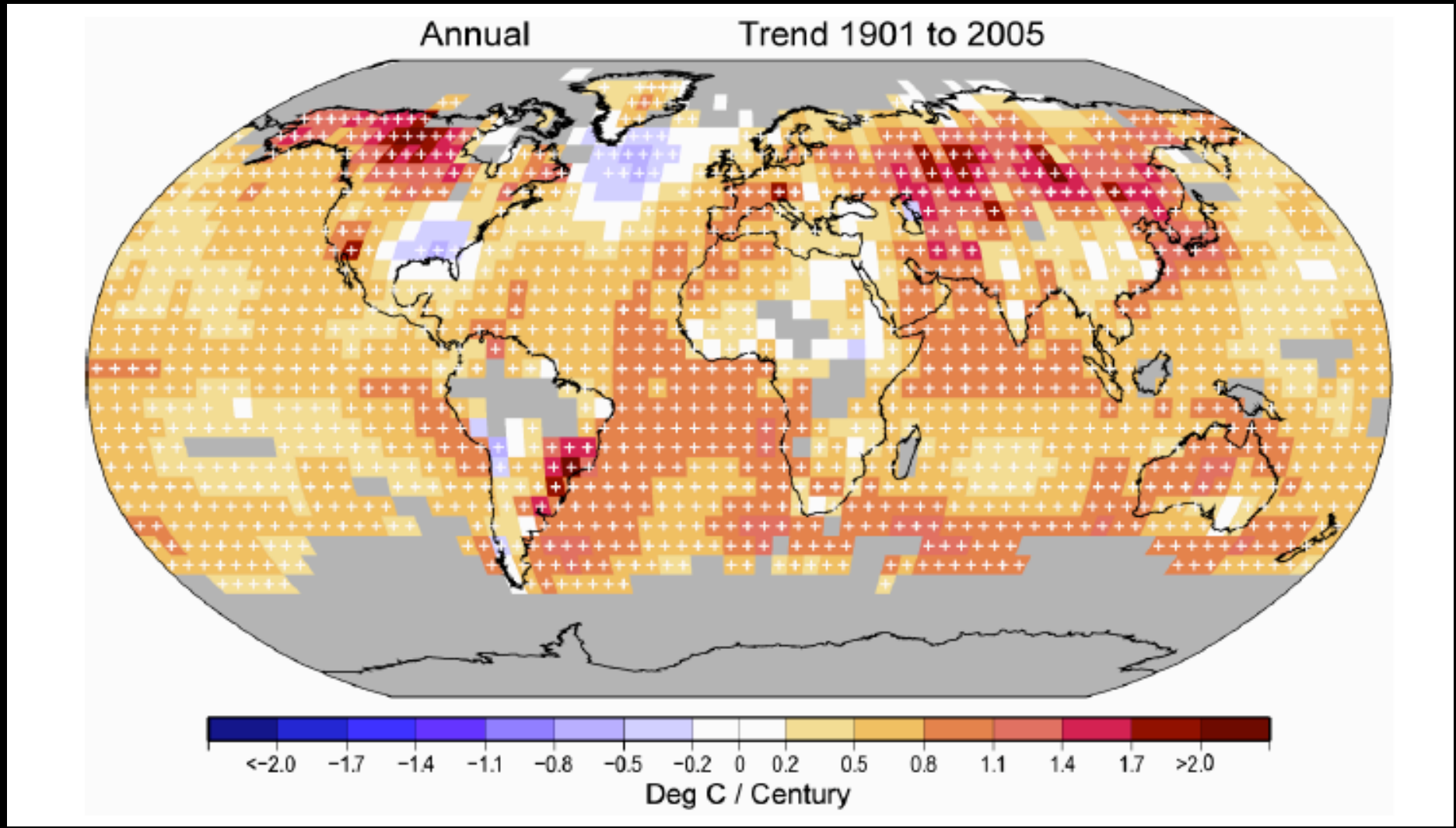
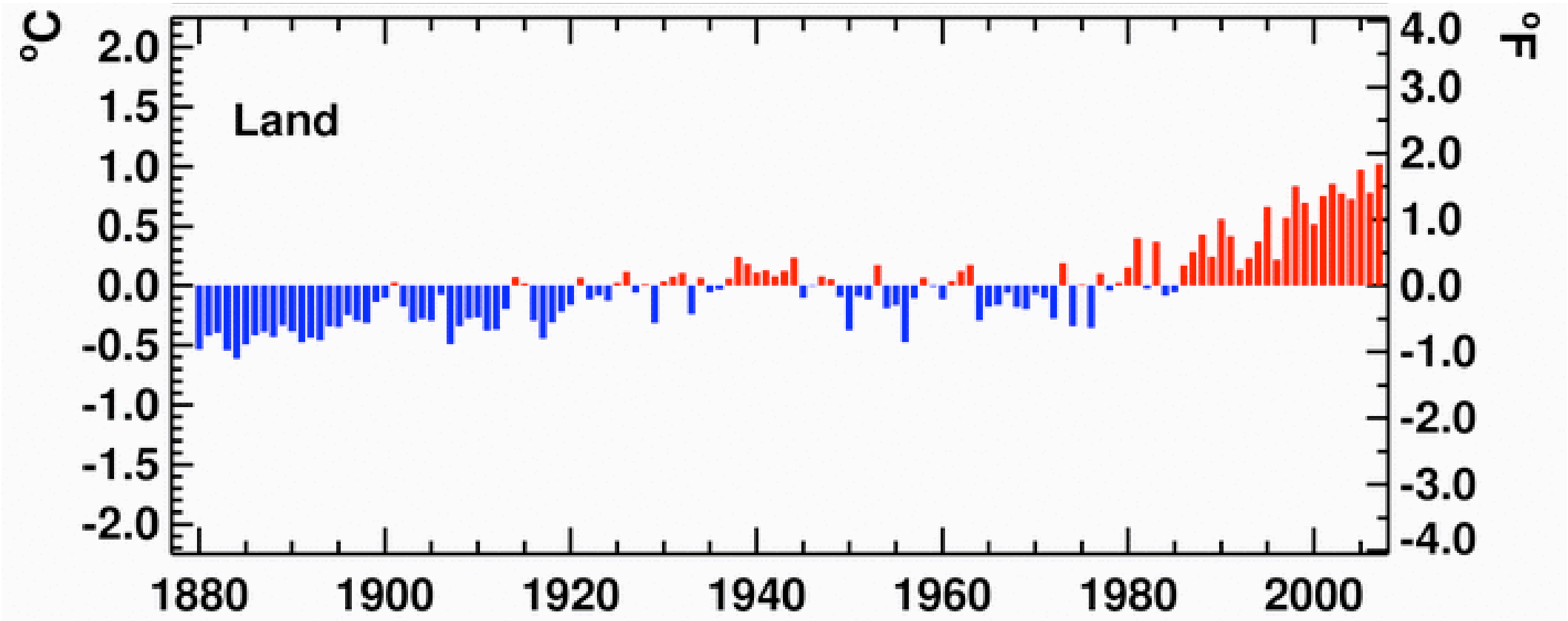
Global warming



Widespread warming has occurred. Globally averaged, the planet is about 0.75°C warmer than it was in 1860, based upon dozens of high-quality long records using thermometers worldwide, including land and ocean.

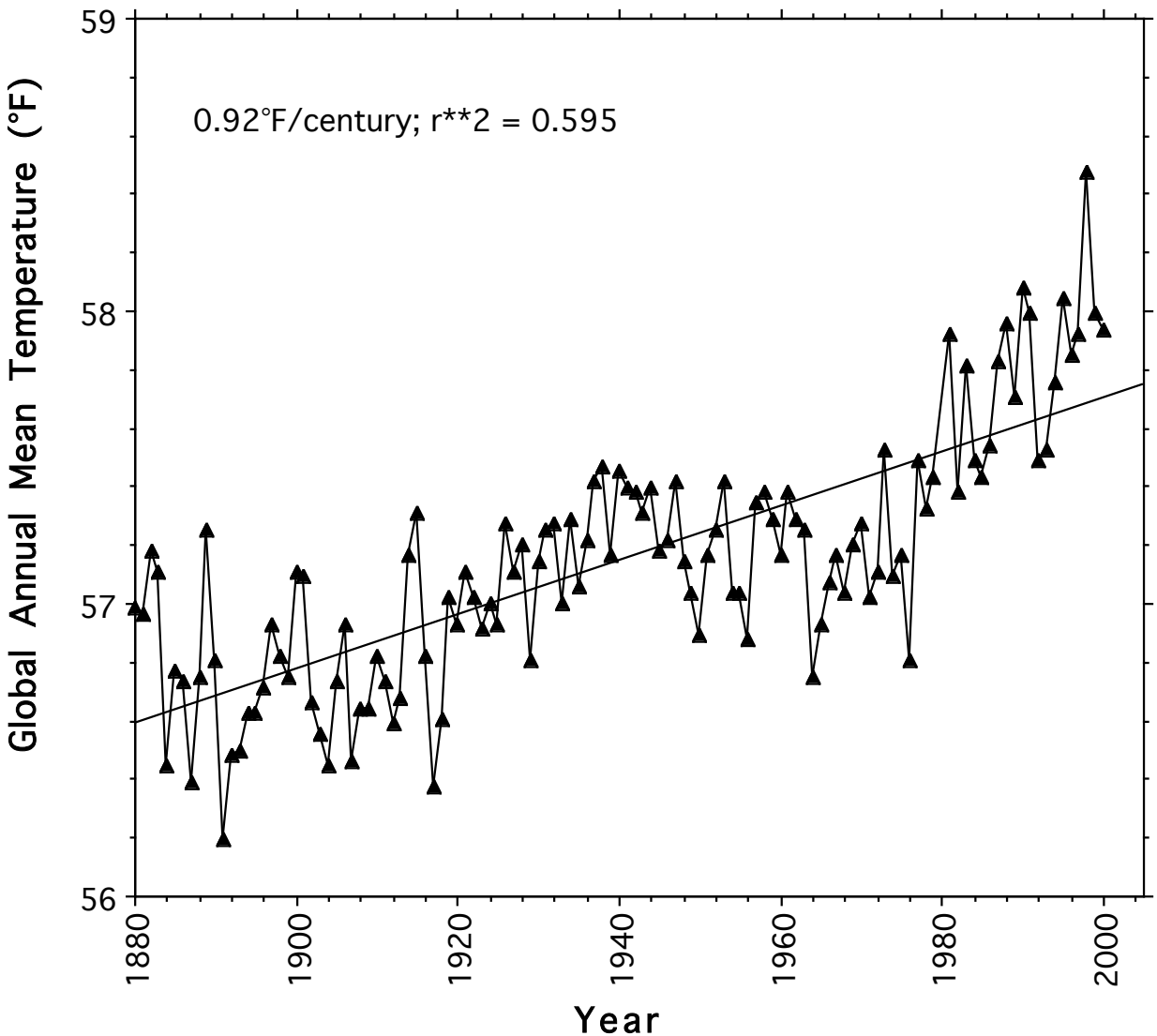
Unequivocal evidence of warming

1880-2007



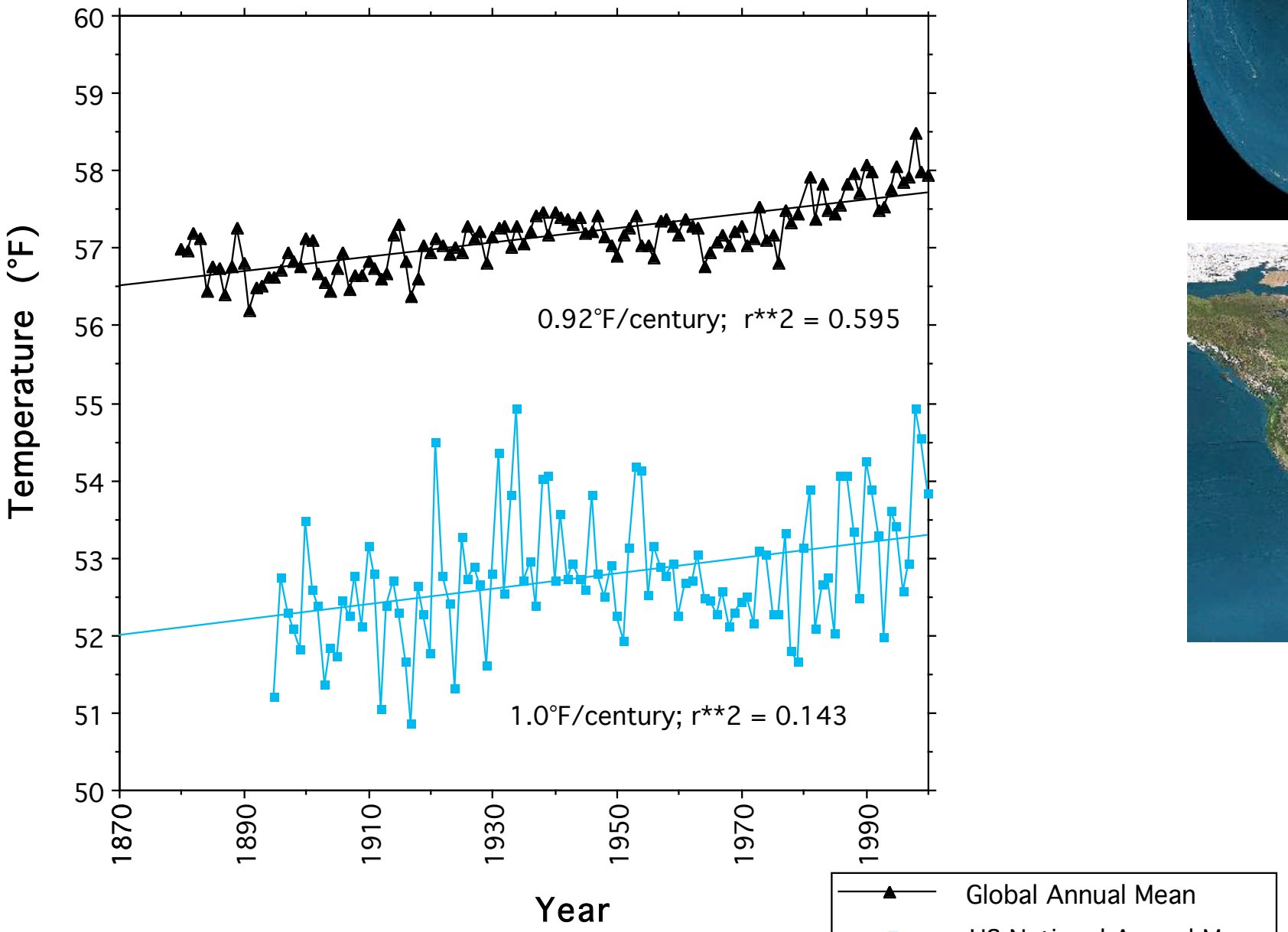
National Climatic Data Center

Global Annual Average Temperatures

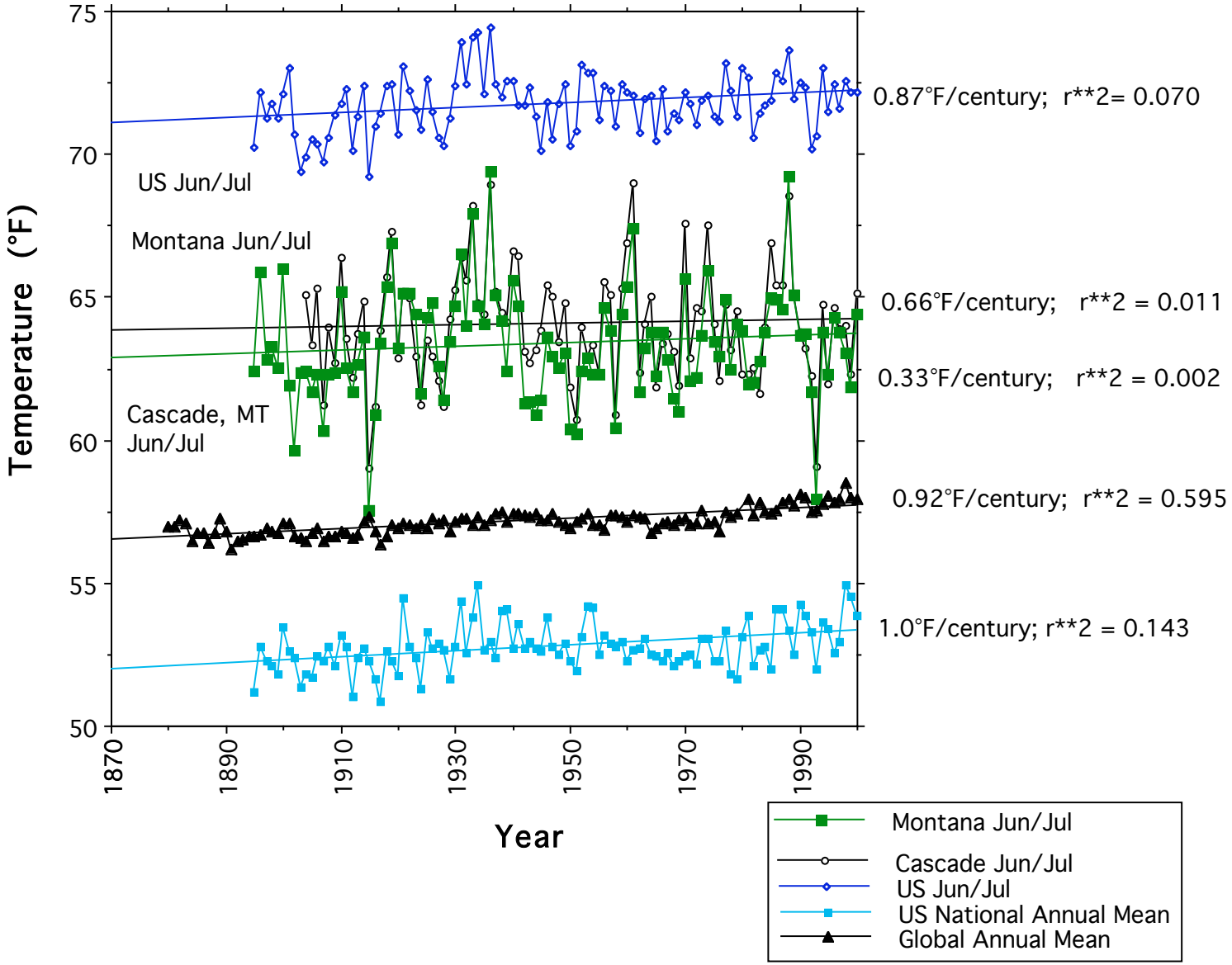


Courtesy Susan Solomon, NOAA

Compared to the USA average….



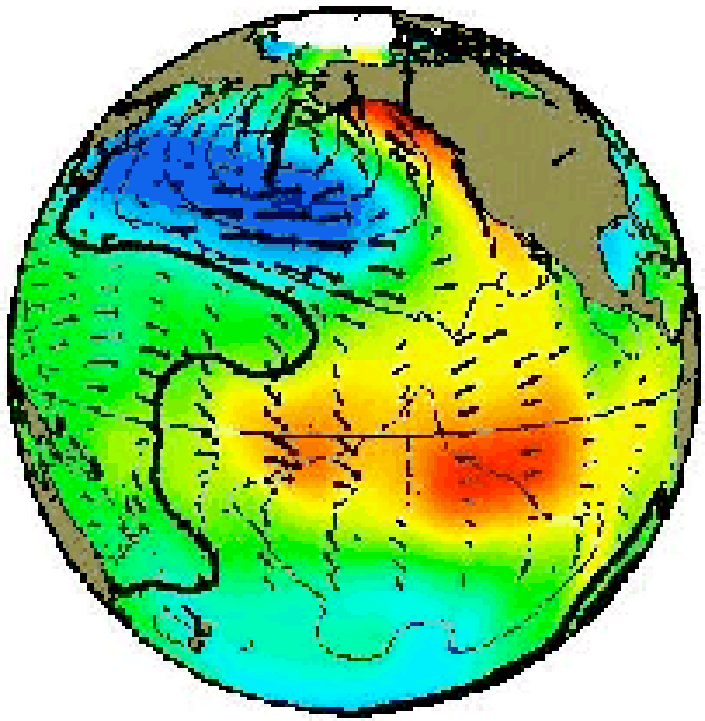
Courtesy Susan Solomon, NOAA

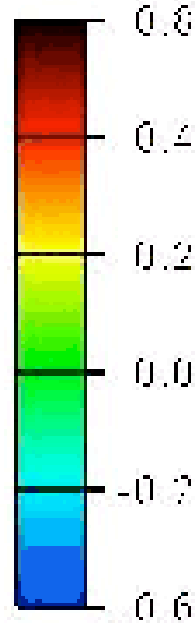


A hot summer does not prove global warming.
A cool spring does not prove global cooling.

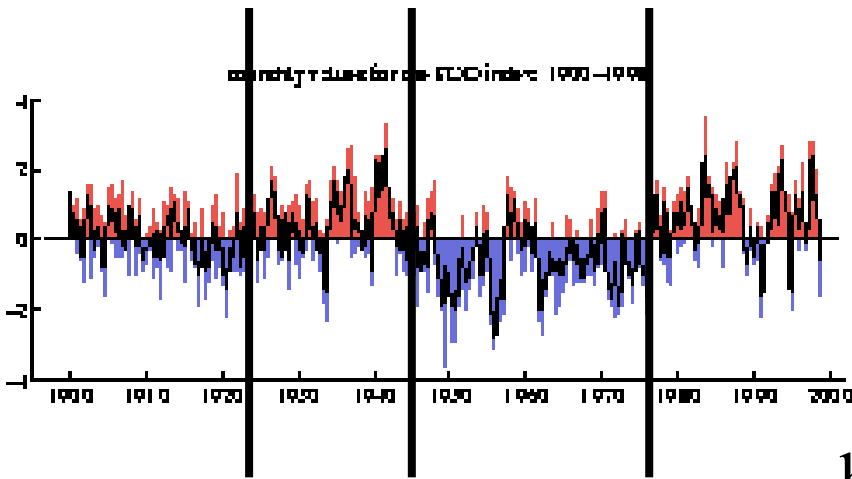
Courtesy Susan Solomon, NOAA

Pacific Decadal Oscillation

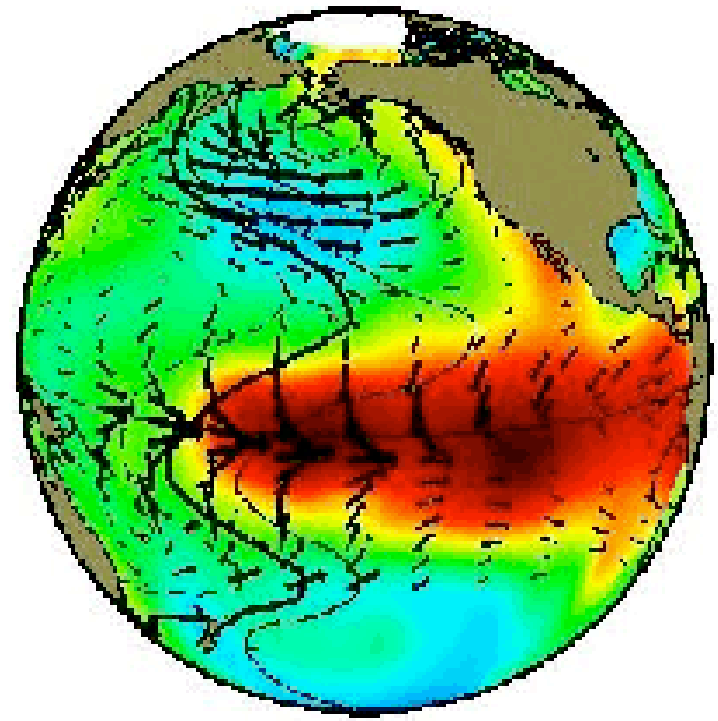


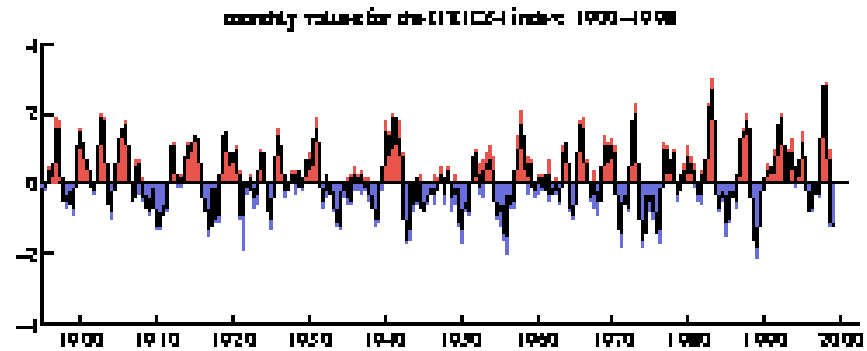


1925 1946 1977



El Niño/Southern Oscillation





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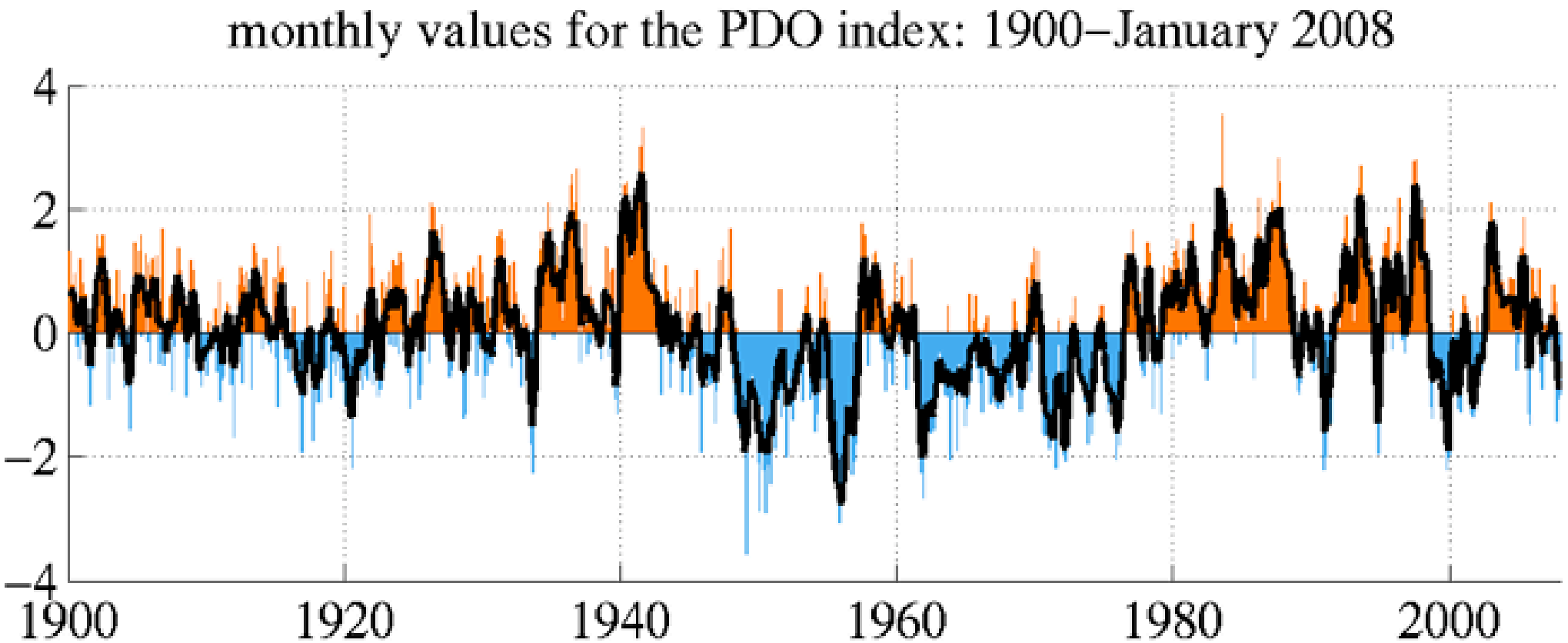

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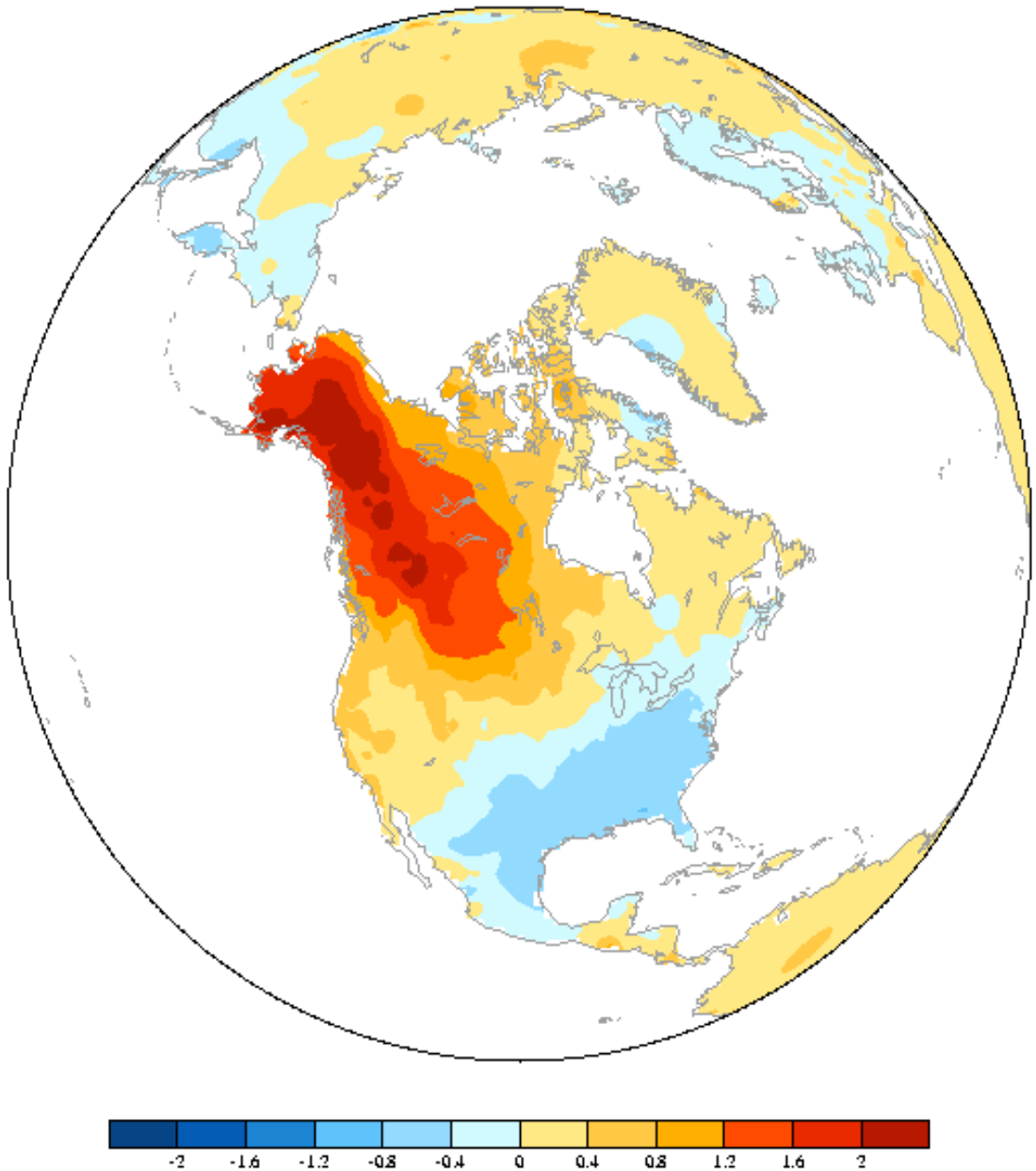
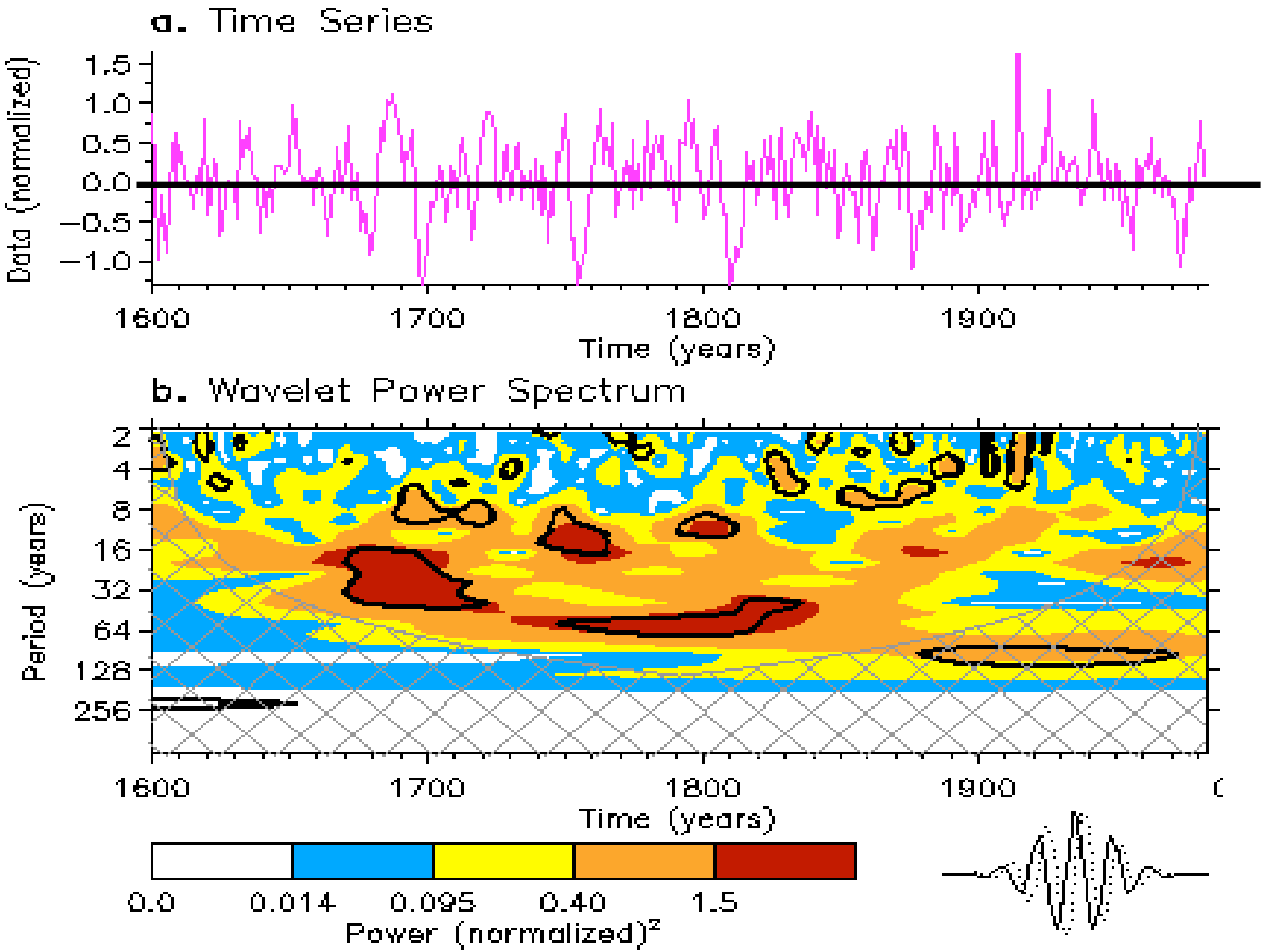
PDO surface air temperature anomalies (C) 1950-96



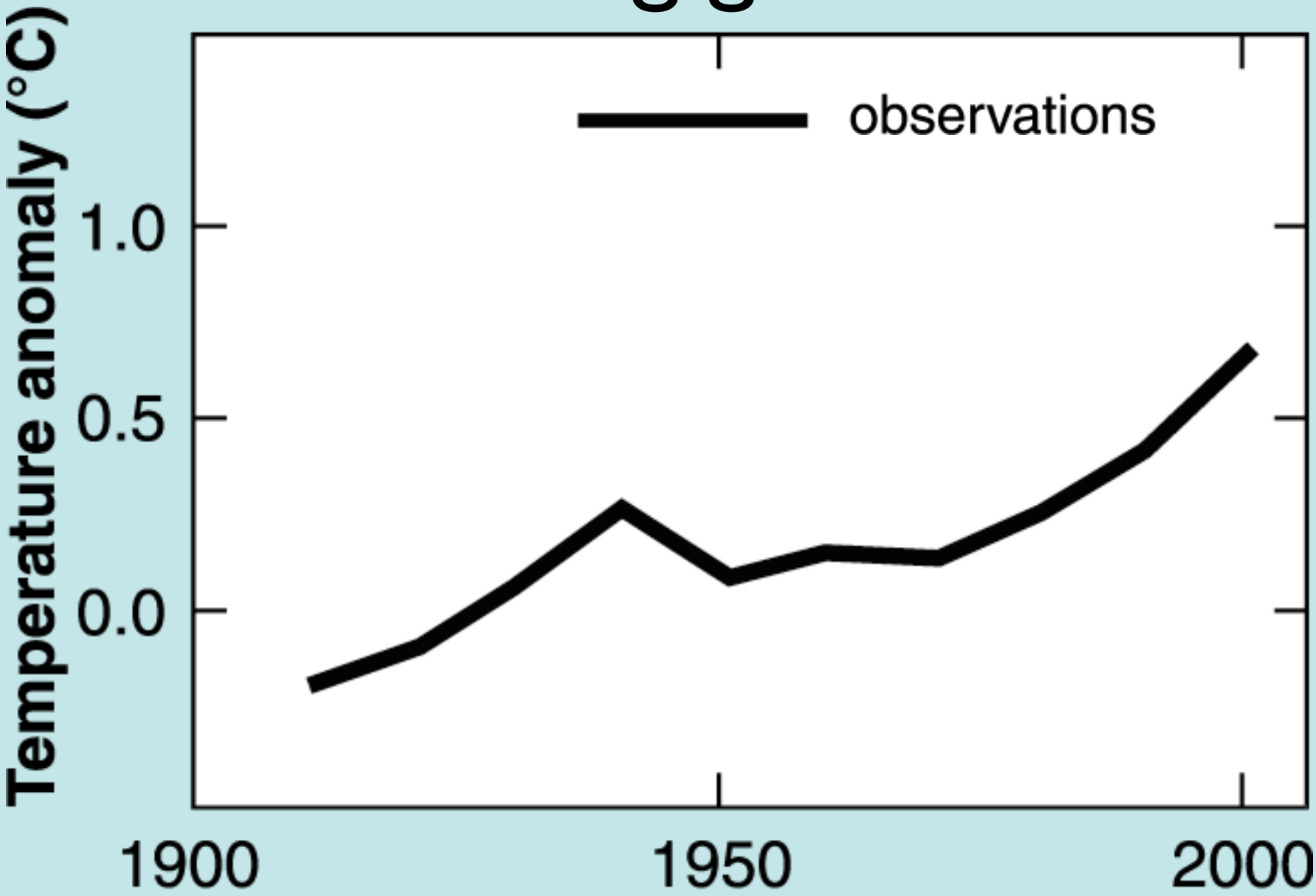
Todd Mitchell, UW/JISAO

Tree-ring based PDO index reconstructions: (ex: Gedalof and Smith 2001)



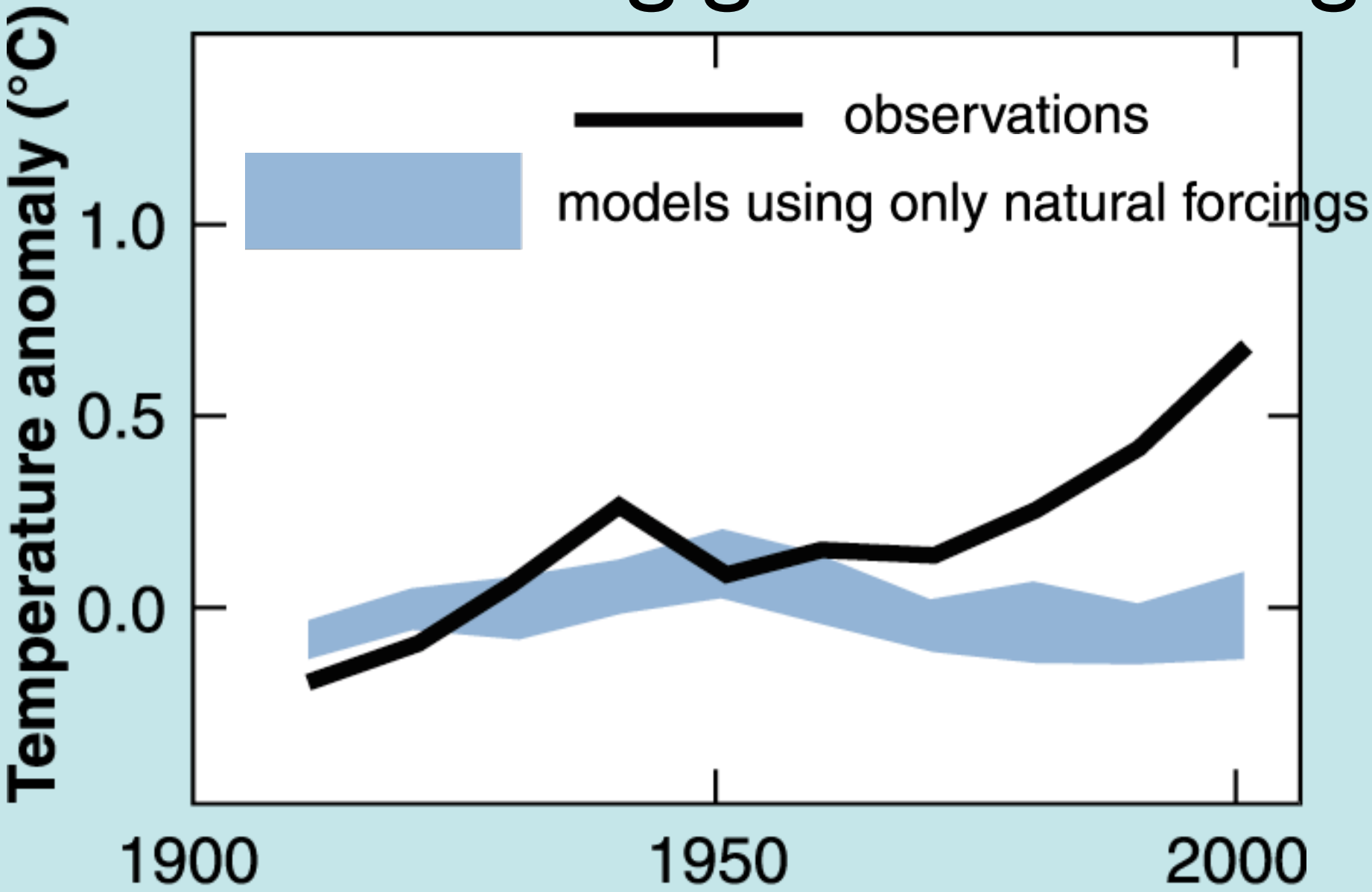
Plots courtesy of Torrence and Compo http://paos.colorado.edu/research/wavelets

Understanding global warming



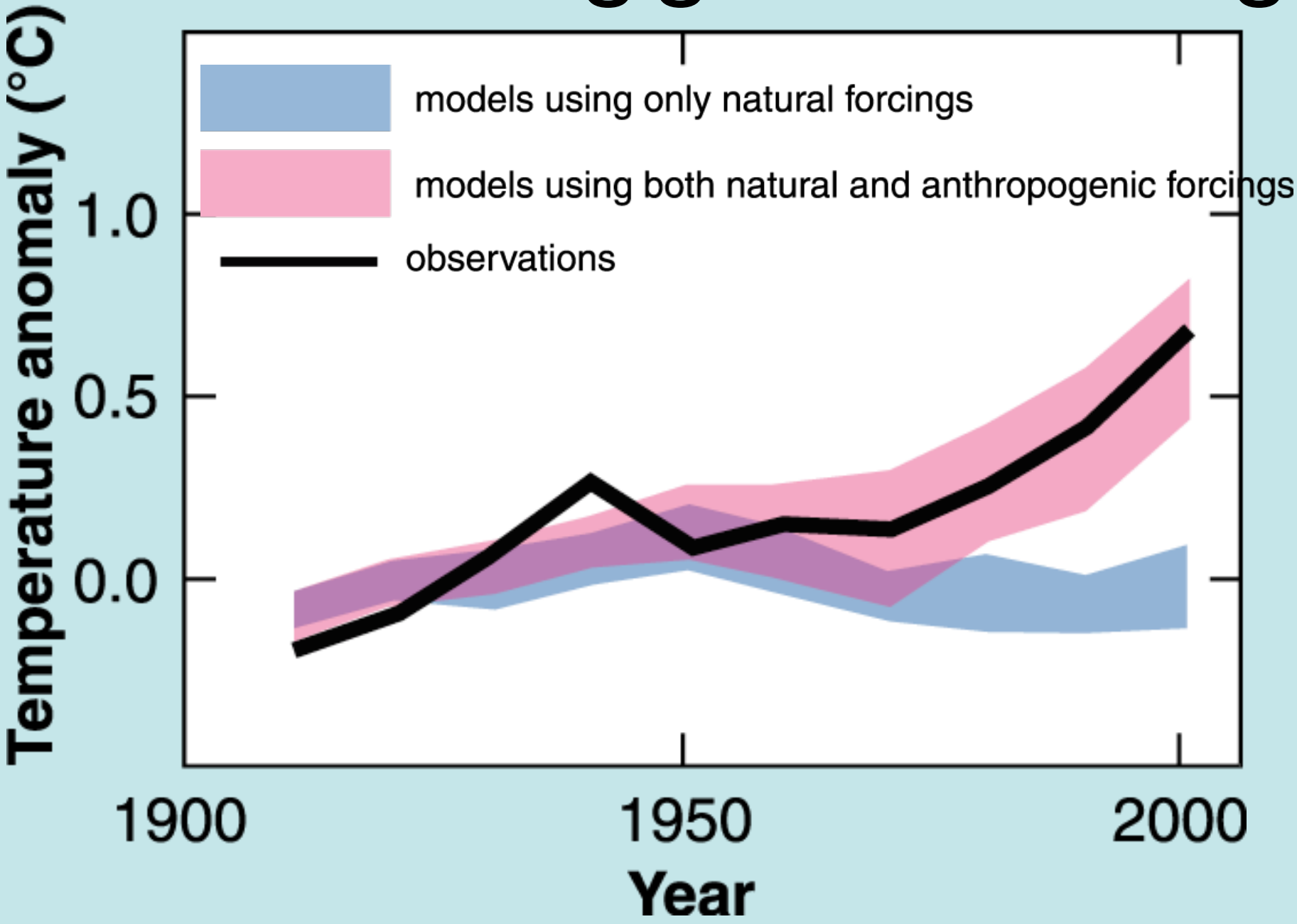
IPCC Summary for Policymakers 2007

Understanding global warming



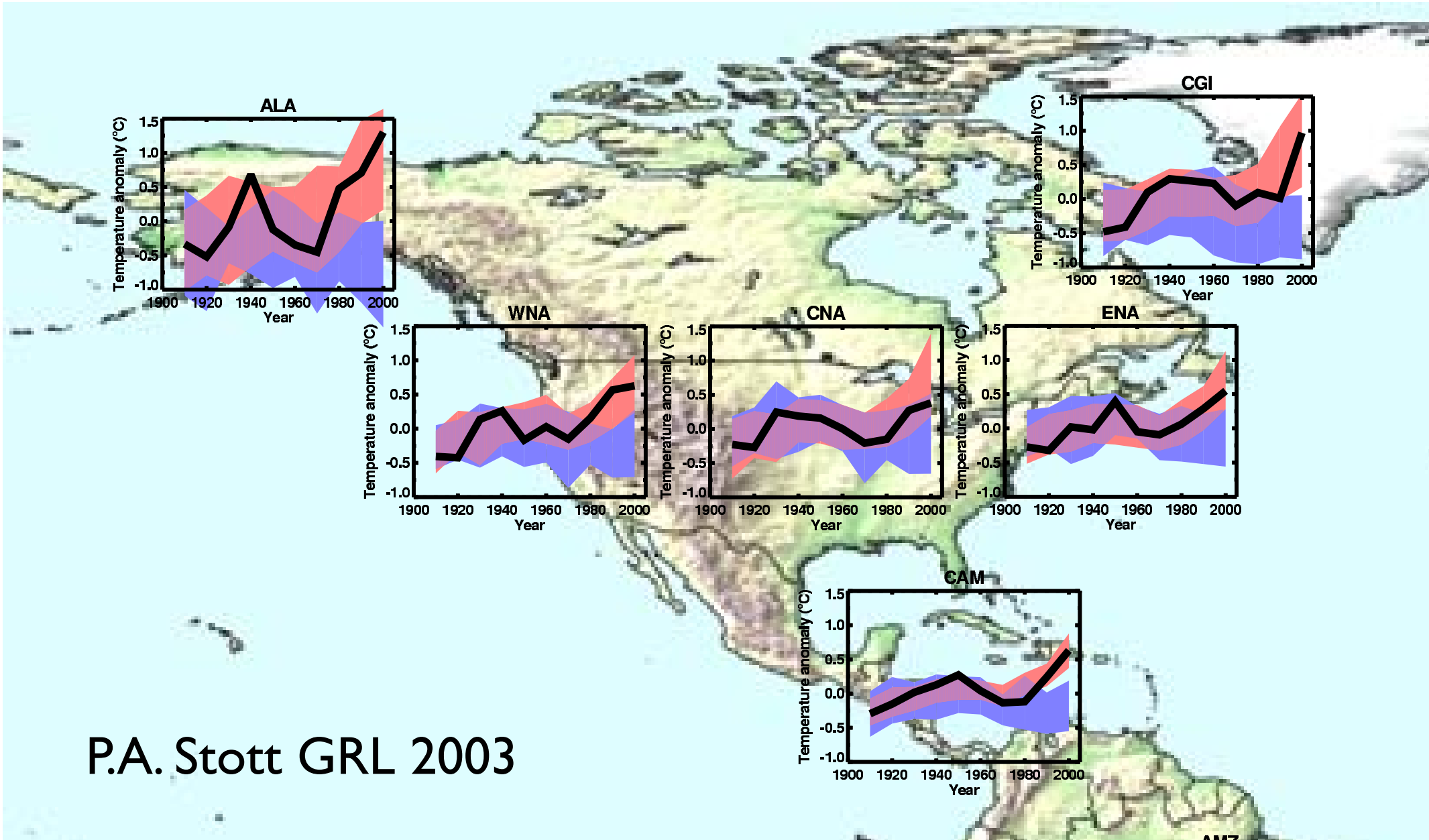
IPCC Summary for Policymakers 2007

Understanding global warming



IPCC Summary for Policymakers 2007

Regional attribution



P.A. Stott GRL 2003

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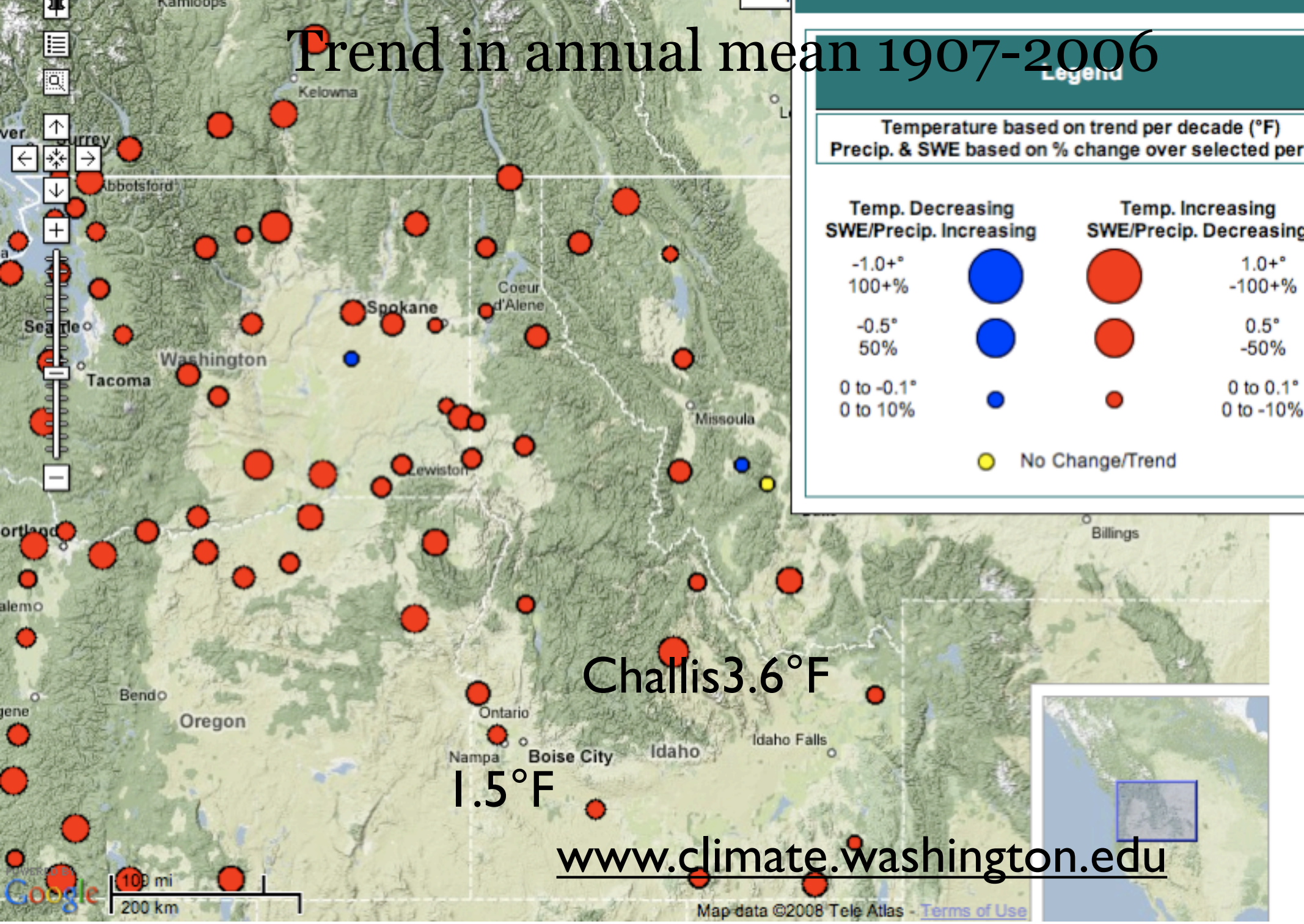
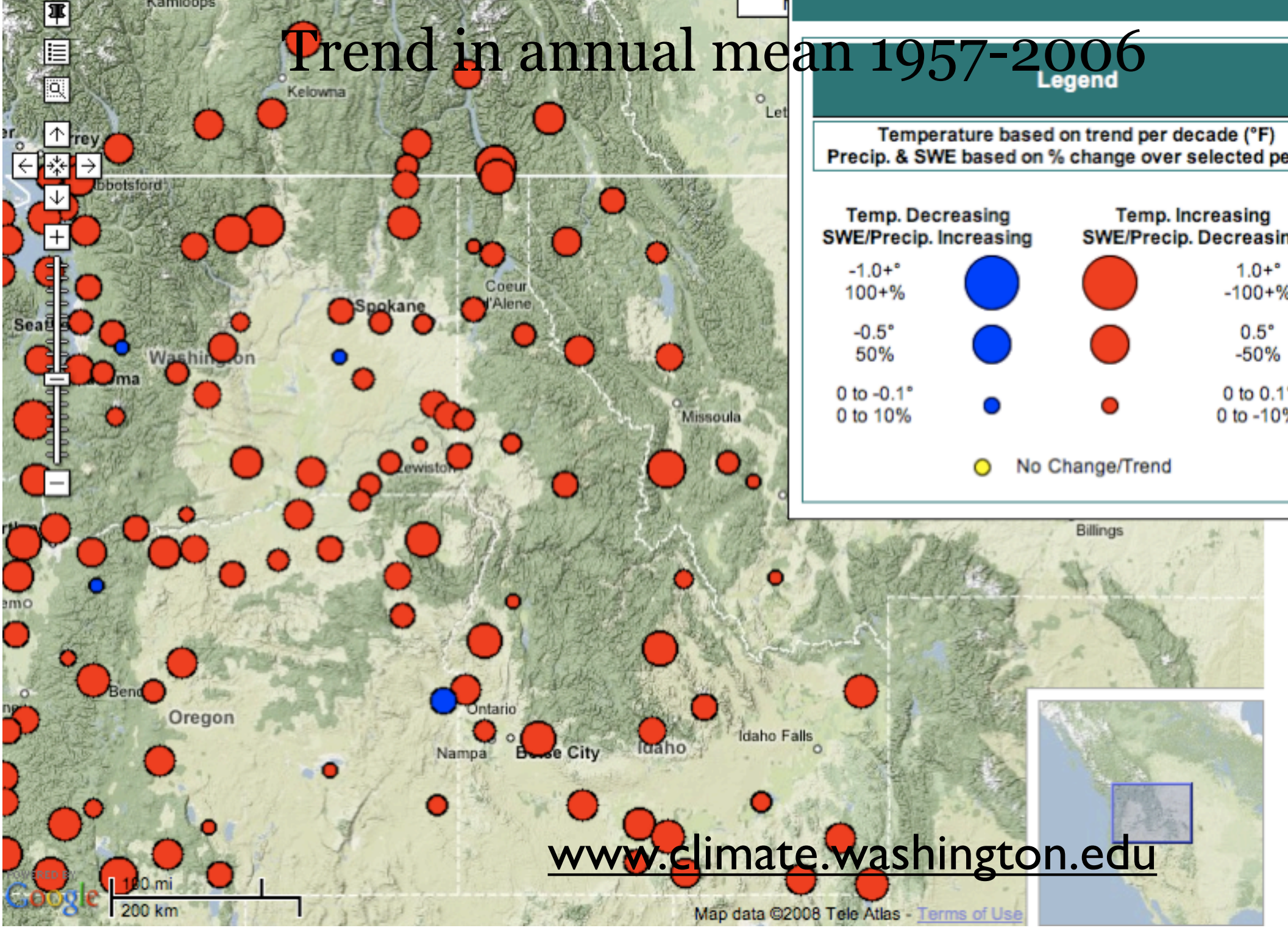
Trend in annual mean 1907-2006

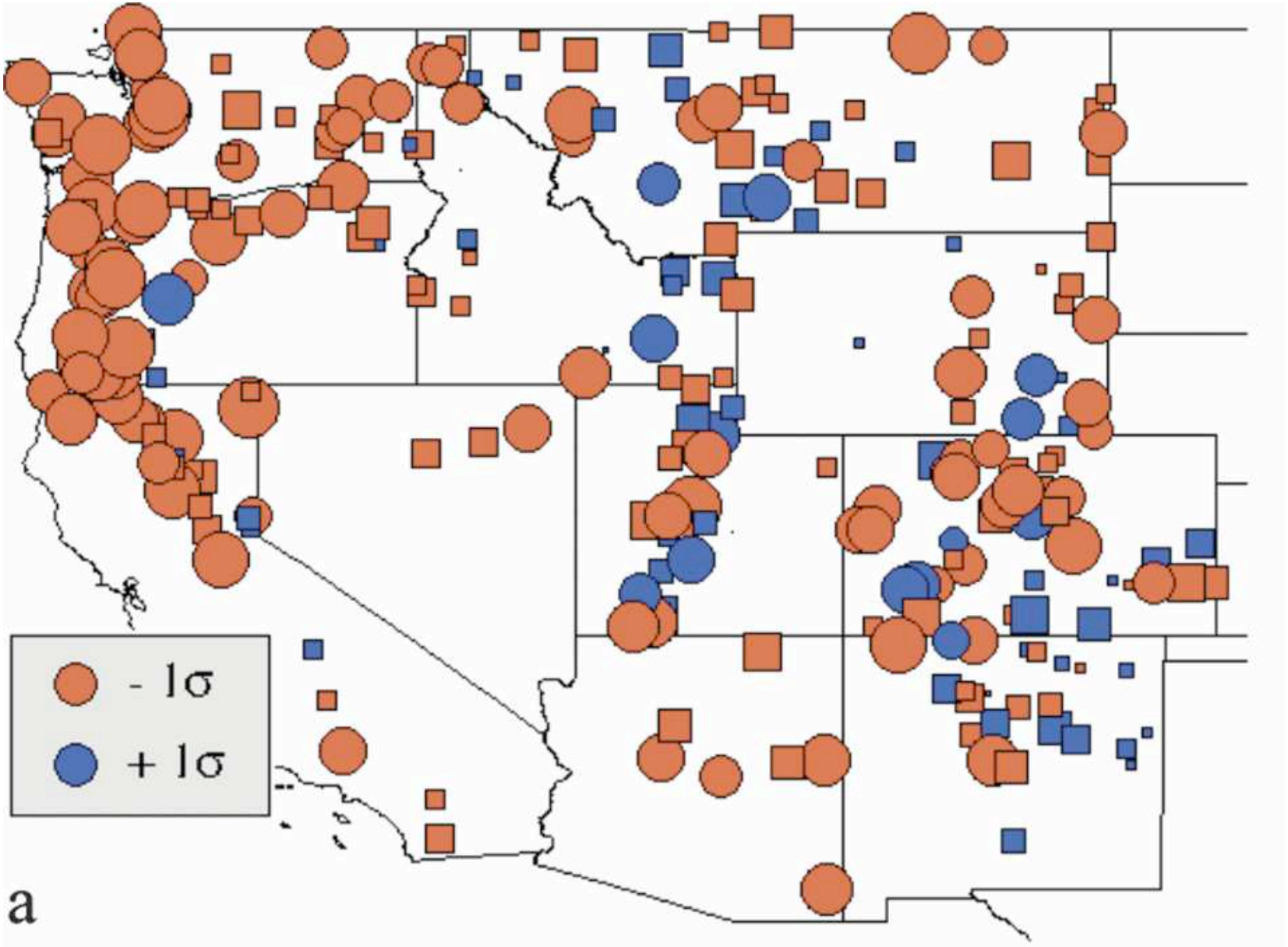


Trend in annual mean 1957-2006



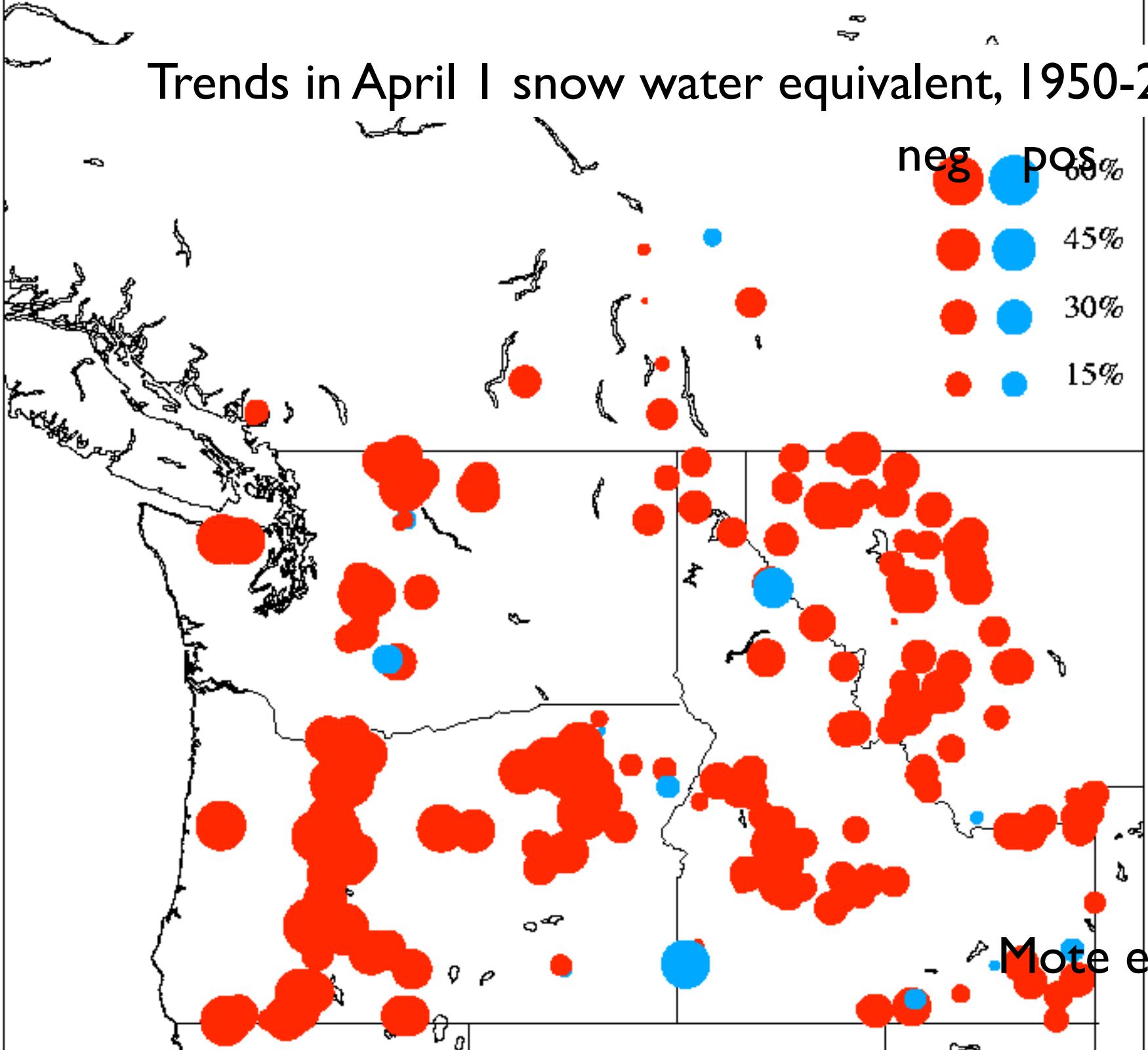
www.climate.washington.edu

Trends in snowfall equivalent

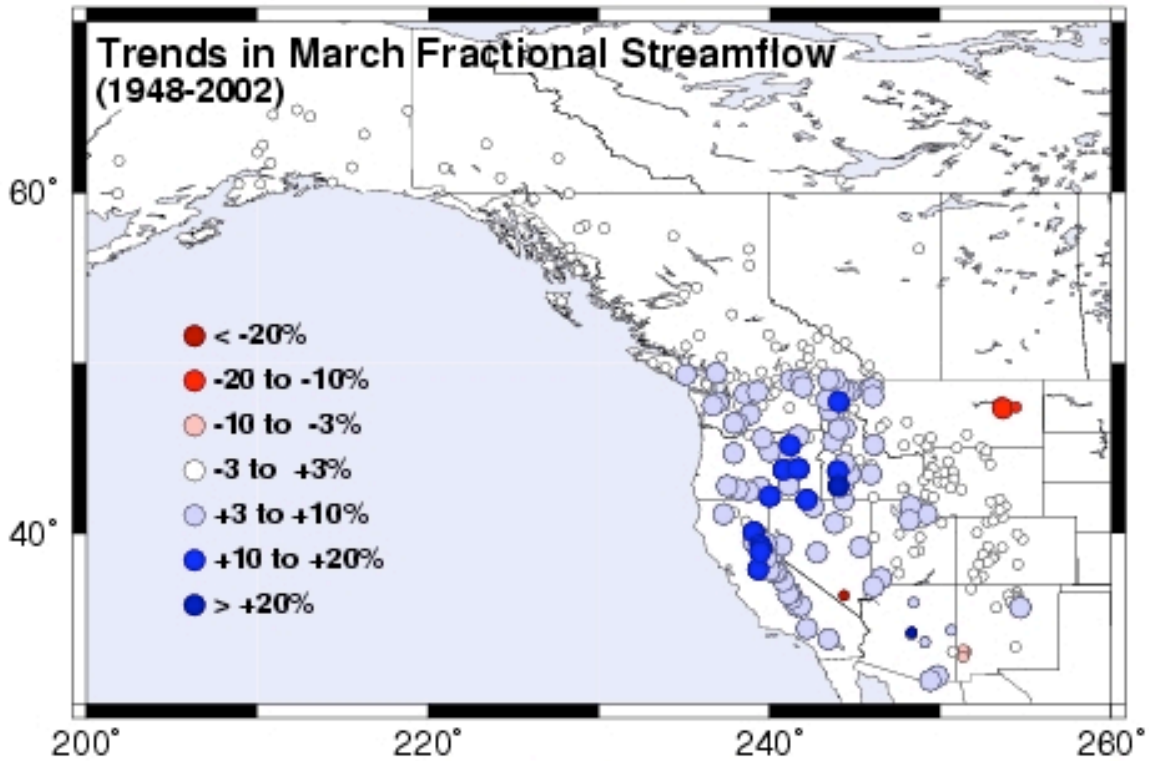


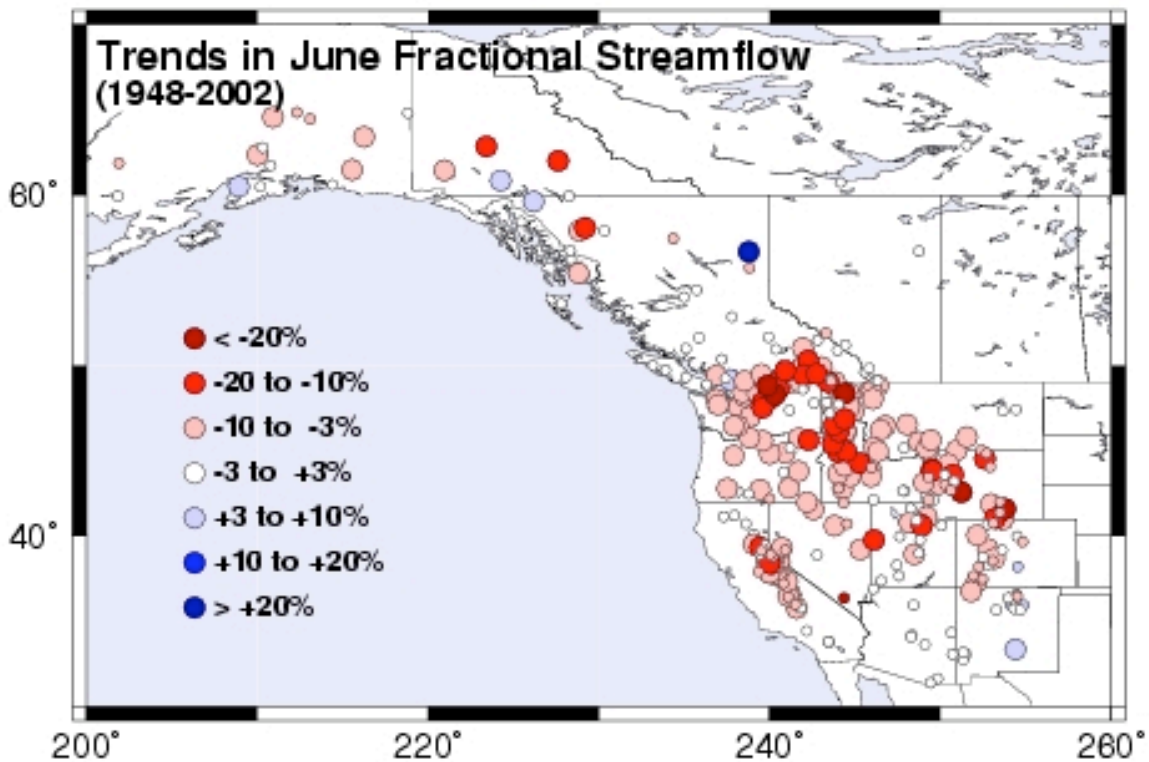
Knowles et al. 2006

Trends in April 1 snow water equivalent, 1950-2000



Mote et al. 2005





As the West warms, winter flows rise and summer flows drop

Stewart et al.
J. Climate 2005

Attribution

"up to 60% of the climate related trends of river flow, winter air temperature and snow pack [in the Western US] between 1950-1999 are human-induced." - Barnett et al. 2008

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Estimating future climate

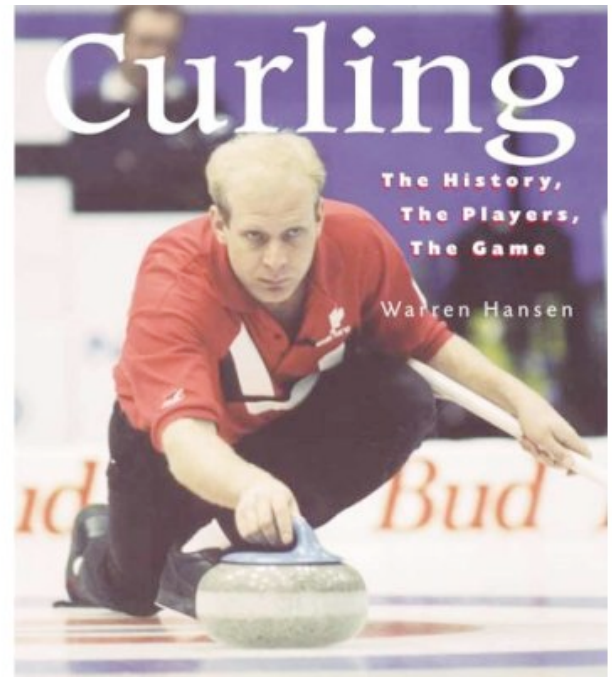
- How much GHGs will there be?

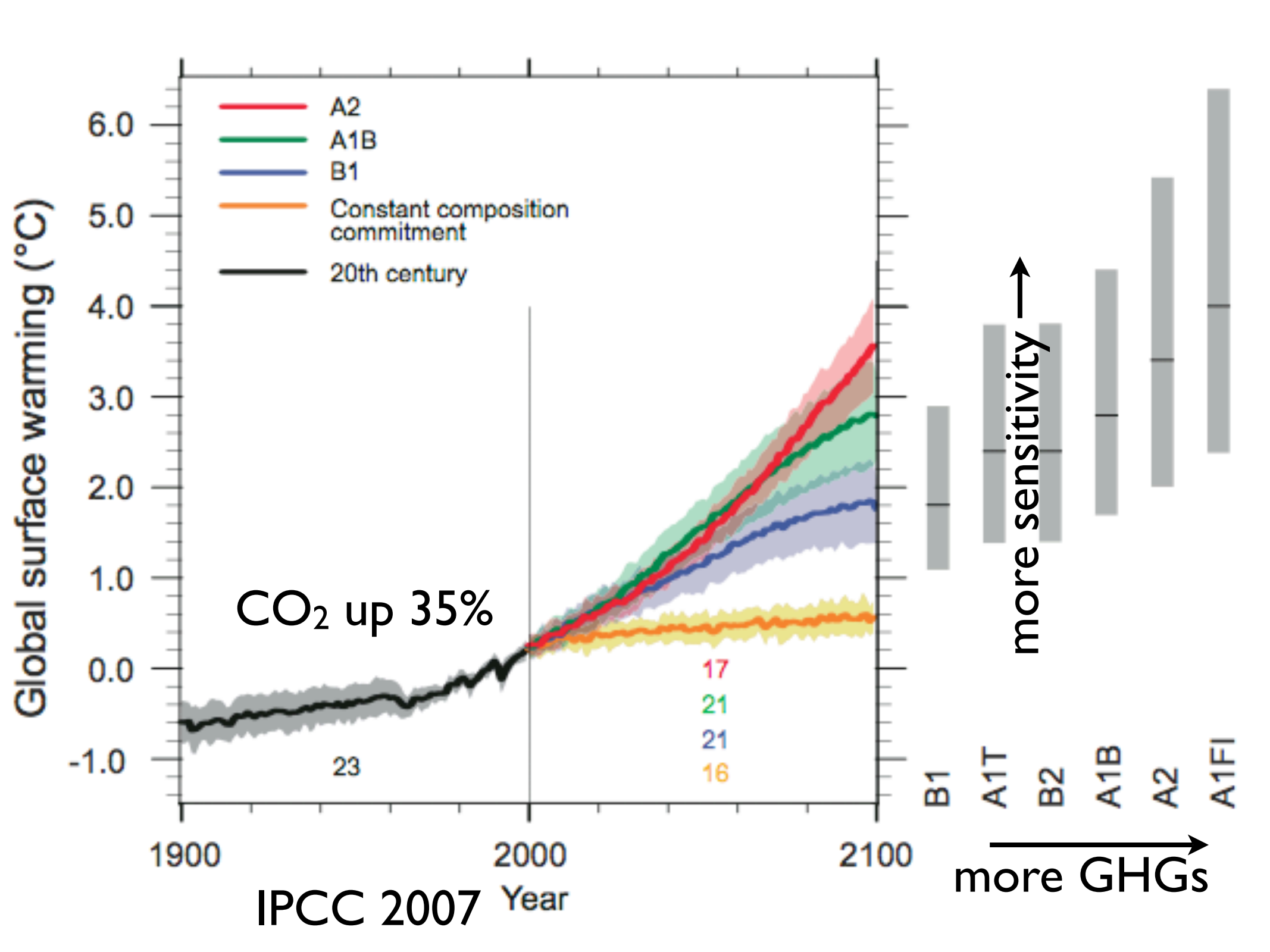
Estimating future climate

- How much GHGs will there be?

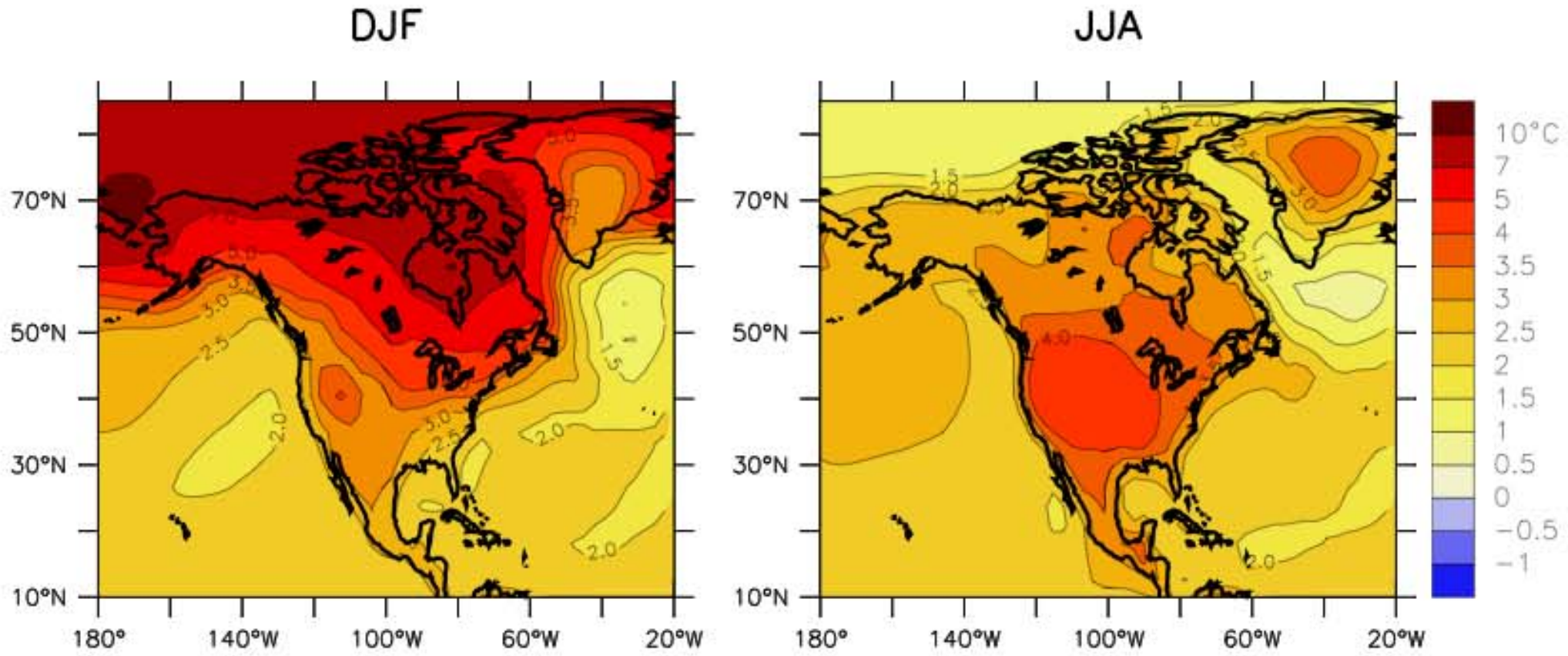
Estimating future climate

- How much GHGs will there be?
- How responsive is the climate?



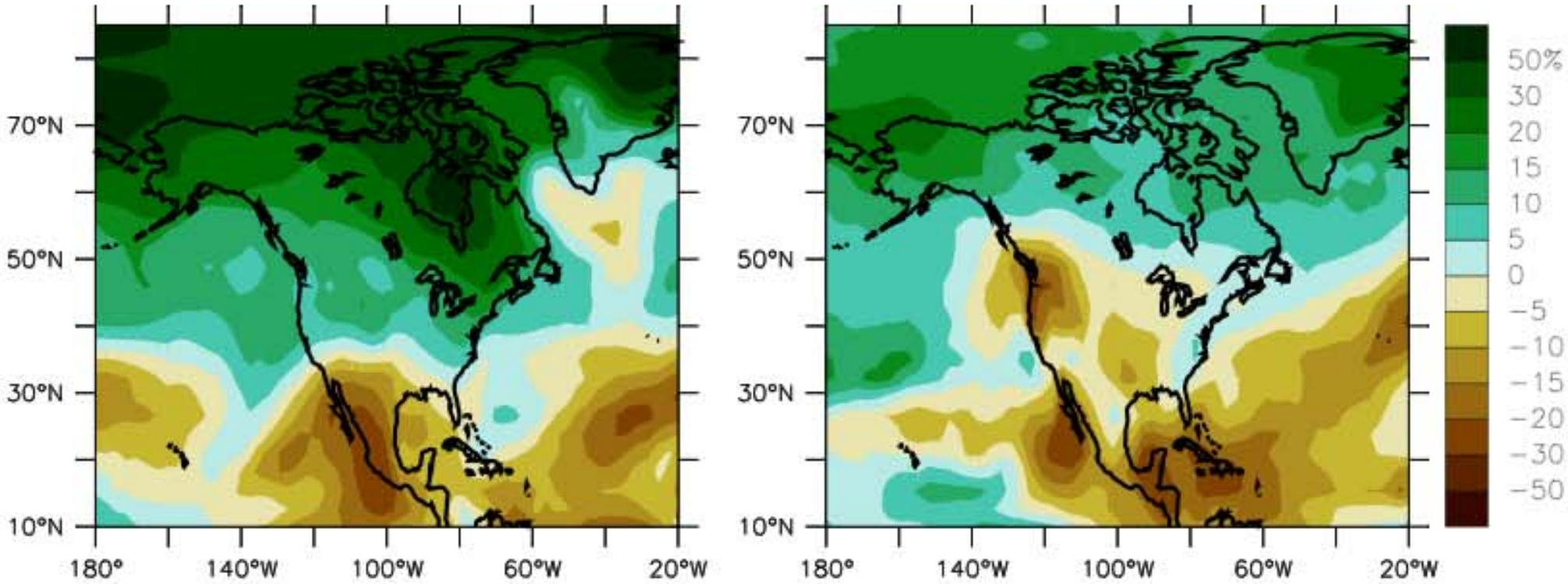

A2
A1B
B1
Constant composition commitment
20th century
Global surface warming (°C)
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
1900
2000
2100
Year
23
17
21
21
16
CO2 up 35%
IPCC 2007
more sensitivity
B1
A1T
B2
A1B
A2
A1FI
more GHGs

Temperature change 2080-99 minus 1980-99

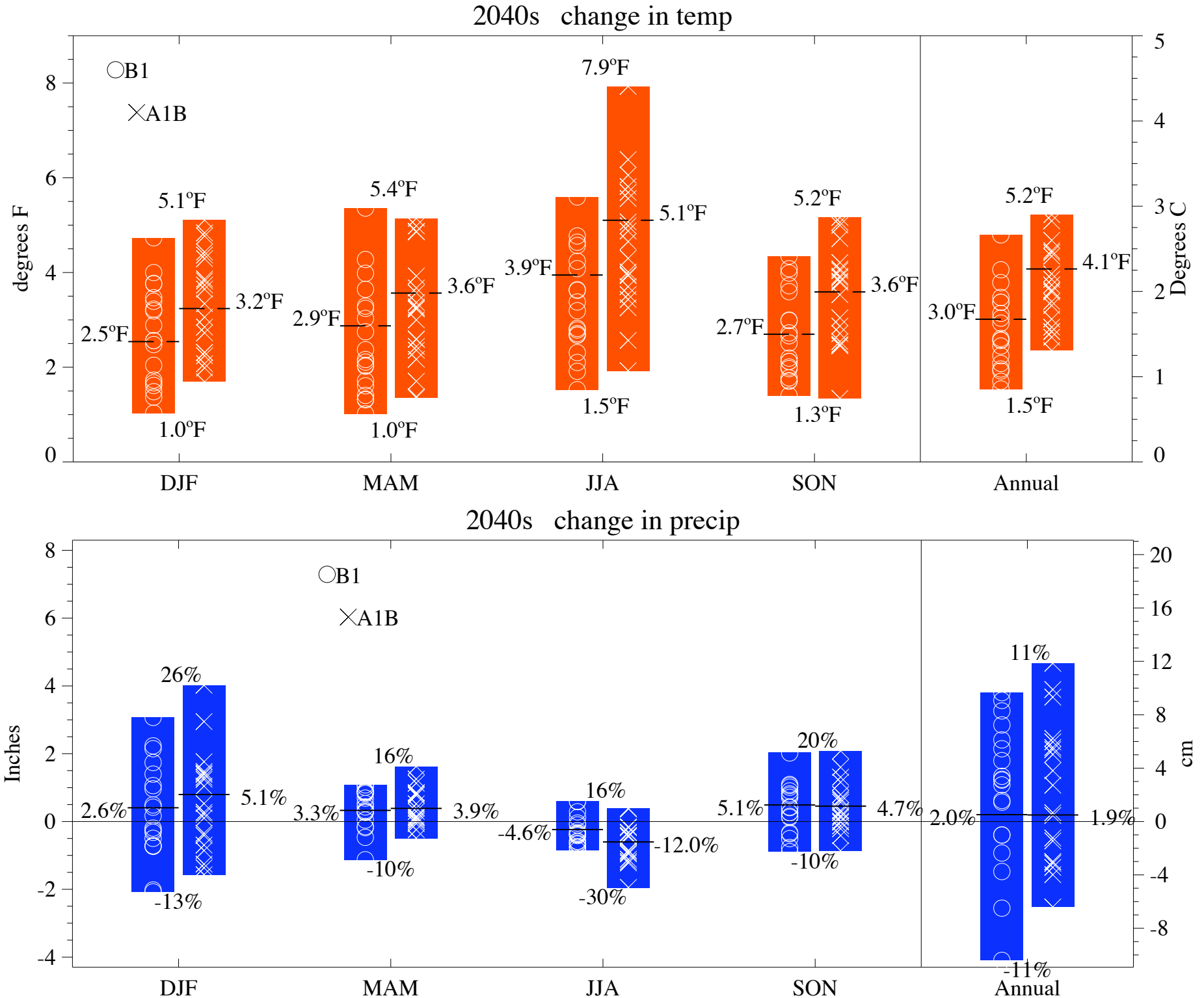


Averaged over 21 global models; IPCC Fig 11.12

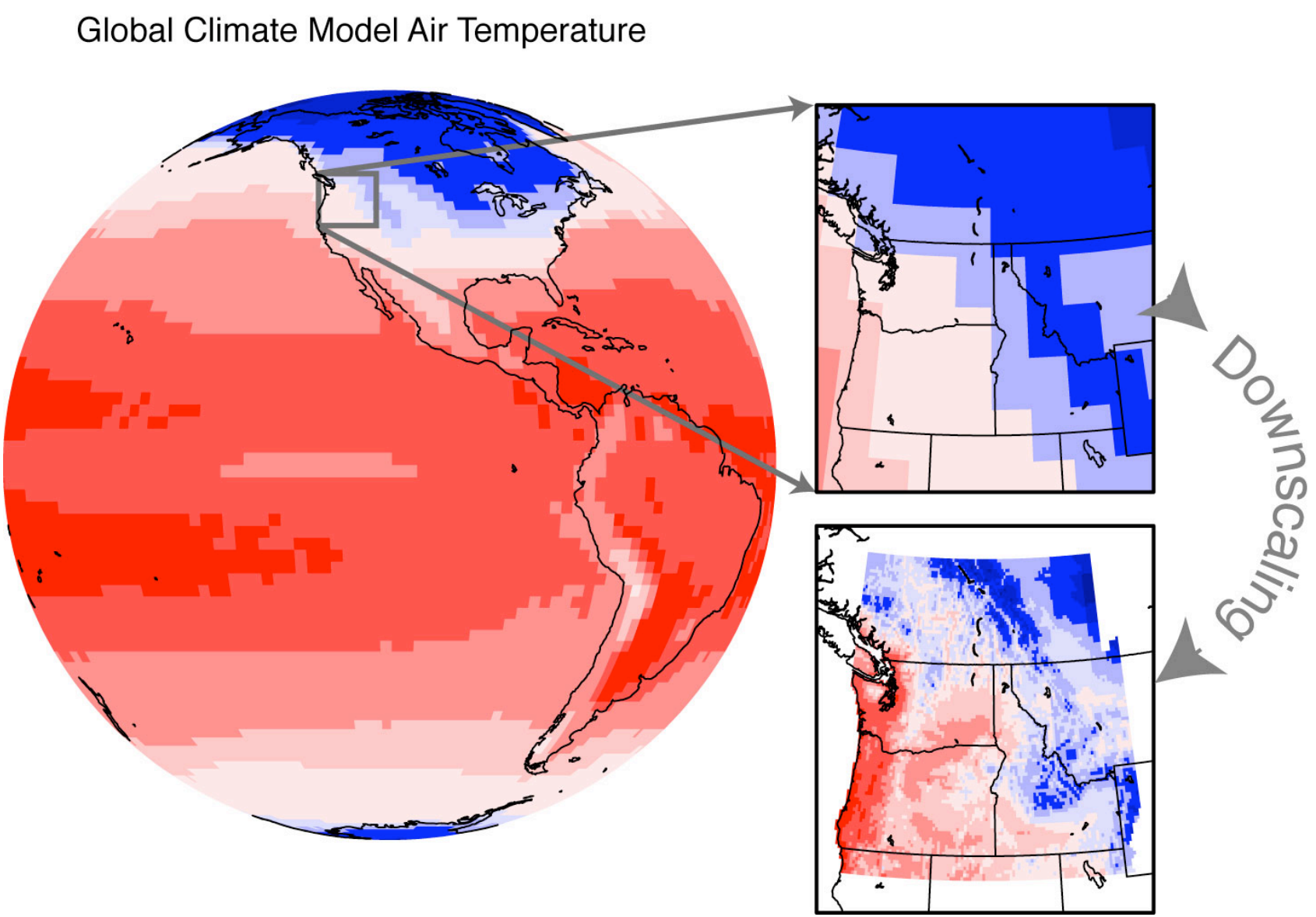
Precipitation change 2080-99 minus 1980-99



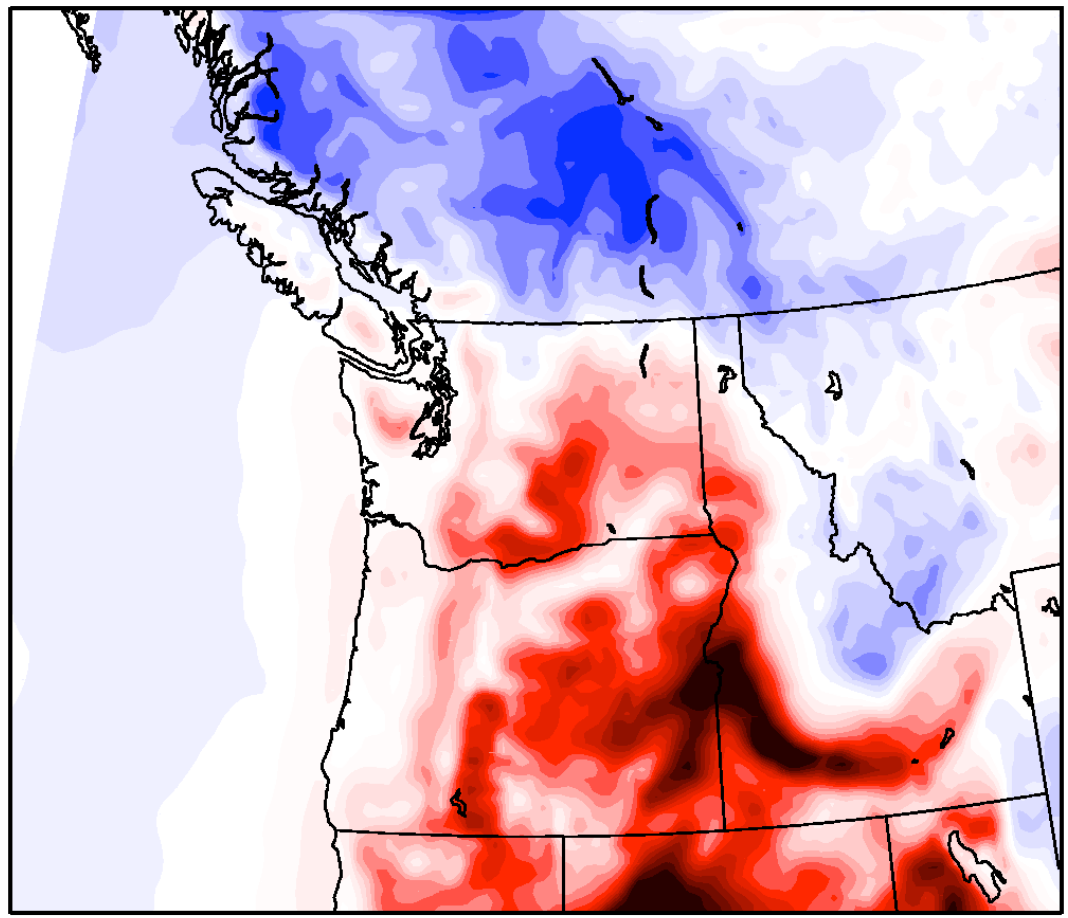
Averaged over 21 global models; IPCC Fig 11.12

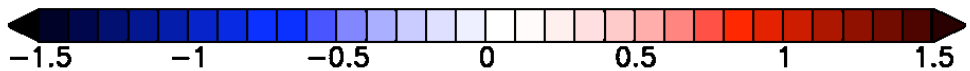

2040s change in temp
B1
A1B
degrees F
Degrees C
5.1°F
2.5°F
3.2°F
1.0°F
5.4°F
2.9°F
3.6°F
1.0°F
7.9°F
3.9°F
5.1°F
1.5°F
5.2°F
2.7°F
3.6°F
1.3°F
5.2°F
3.0°F
4.1°F
1.5°F
DJF
MAM
JJA
SON
Annual
2040s change in precip
B1
A1B
Inches
cm
26%
2.6%
5.1%
-13%
16%
3.3%
3.9%
-10%
16%
-4.6%
-12.0%
-30%
20%
5.1%
4.7%
-10%
11%
2.0%
1.9%
-11%
DJF
MAM
JJA
SON
Annual

Downscaling



Texture of warming: Regional model minus global model for 2050s





Difference in projected winter temperature (°C)

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Conclusions

- human influence on climate emerging from noise at smaller scales (western N. Am.)
- Observed PNW changes: 1.5°F warming, corresponding hydrologic shifts
- Future climate: 0.5°F/decade warmer, precip?, rest depends on us